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Safety and certainty in the design of roads

Christoph Hupfer¹

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Abstract

In many places we experience a cycling infrastructure that is not sufficiently safe and/or is perceived as not sufficiently safe. But the needs of cyclists seem to be well known. The existing regulations offer a sufficient wealth of knowledge and infrastructure elements. However, these aspects have to be weighed against each other and against additional demands. Decisions on the design of road spaces are made with local political participation, often by committed laypeople. The abundance of criteria and their weighting, which are defined in the regulations for engineers and planners, seem to overwhelm the decision-makers or do not sufficiently address them. Uncertainty in decision-making fosters a lack of road safety in infrastructure. There is a need for a more suitable decision-making basis for the construction of infrastructure that addresses a responsible decision by the laypersons involved outside of the numerous technical criteria and their weighing against each other or against each other and supports decision-making more strongly.

In the following, an approach from planning practice is presented based on two exemplary situations, which requires systematic validation. Here, a joined approach of engineering sciences and social psychology could provide suitable assistance for better decisions in the sense of a stronger development towards sustainability and quality of life.

Practical Relevance: The redesign of traffic facilities for more bicycle and pedestrian traffic and the design of urban street spaces towards living spaces are a particular challenge. It is important that expert planners offer guiding questions to decision-makers. These must focus on the goals and the achievement of goals for the people for whom the goals have been set. This leads to more goal-focused decisions and more goal-directed effective change.

Keywords Infrastructure design · Cycling · Decision-making process · Consideration process · Road safety

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Sicherheit bei der Gestaltung von Straßen

Zusammenfassung

Vielerorts erleben wir eine Radverkehrsinfrastruktur, die nicht ausreichend sicher ist und/oder als nicht ausreichend sicher empfunden wird. Die Bedürfnisse der Radfahrer scheinen jedoch bekannt zu sein. Die bestehenden Vorschriften bieten eine ausreichende Fülle an Wissen und Infrastrukturelementen. Diese Aspekte müssen jedoch gegeneinander und gegen zusätzliche Anforderungen abgewogen werden. Entscheidungen über die Gestaltung von Straßenräumen werden unter kommunalpolitischer Beteiligung getroffen, oft von engagierten Laien. Die Fülle der Kriterien und deren Gewichtung, die in den Regelwerken für Ingenieure und Planer festgelegt sind, scheinen die Entscheidungsträger zu überfordern oder gehen nicht ausreichend auf sie ein. Die Unsicherheit bei der Entscheidungsfindung begünstigt einen Mangel an Verkehrssicherheit in der Infrastruktur. Es bedarf einer geeigneteren Entscheidungsgrundlage für den Bau von Infrastruktur, die eine verantwortungsvolle Entscheidung der beteiligten Laien jenseits der zahlreichen technischen Kriterien und deren Abwägung untereinander oder gegeneinander anspricht und die Entscheidungsfindung stärker unterstützt.

Im Folgenden wird anhand von zwei exemplarischen Situationen ein Ansatz aus der Planungspraxis vorgestellt, der einer systematischen Absicherung bedarf. Hier könnte ein gemeinsamer Ansatz von Ingenieurwissenschaften und Sozialpsychologie geeignete Hilfestellungen für bessere Entscheidungen im Sinne einer stärkeren Entwicklung in Richtung Nachhaltigkeit und Lebensqualität liefern.

Praktische Relevanz: Die Umgestaltung von Verkehrsanlagen für mehr Rad- und Fußverkehr sowie die Gestaltung von städtischen Straßenräumen hin zu Lebensräumen sind eine besondere Herausforderung. Es ist wichtig, dass Fachplanende den Entscheidungstragenden wegweisende Fragen anbieten. Diese müssen die Ziele und die Zielerreichung für die Menschen, für welche die Ziele gesetzt wurden, in den Mittelpunkt stellen. Dies führt zu zielgerichteteren Entscheidungen und wirksamen Veränderungen.

Schlüsselwörter Infrastrukturgestaltung · Radfahren · Entscheidungsprozess · Abwägungsprozess · Verkehrssicherheit

1 Many competing requirements and rules

There is a wealth of guidelines and rules for the design of roads, the application of which enables a situation- and user-specific design of the respective roads (extra-urban) or road spaces (urban), including a high level of road safety. In doing so, a multitude of requirements have to be taken into account and objectives have to be met:

- Road safety,
- Traffic quality and
- Environmental compatibility

out of town (Hartkopf et al. 2017). In towns (Baier et al. 2006)

- serviceability including accessibility,
- Streetscape design and
- Environmental compatibility

added. Furthermore, the costs have to be included in the considerations. In addition to the planning and design aspects, there are other extraneous framework conditions. These range from the ownership of required land, existing pipelines in the road, different responsibilities and financing conditions to the protection of nature and landscape.

As a result, the large number of decisions to weigh up the various factors has also led to projects and measures being implemented in which road safety has been disad-

vantaged in comparison to other criteria. In response to this, the safety audit (Lemke et al. 2019) was introduced in Germany in the implementation of European directives (Directive 2008/96/EC 2008), which is to be applied to the design of new roads or the reconstruction of existing roads. This does not formulate any additional requirements in terms of content, but rather focuses on the application of the existing directives in terms of safety.

Another set of regulations that must not be forgotten is the Road Traffic Act with its associated administrative regulations, which increasingly refer to the application of the directives.

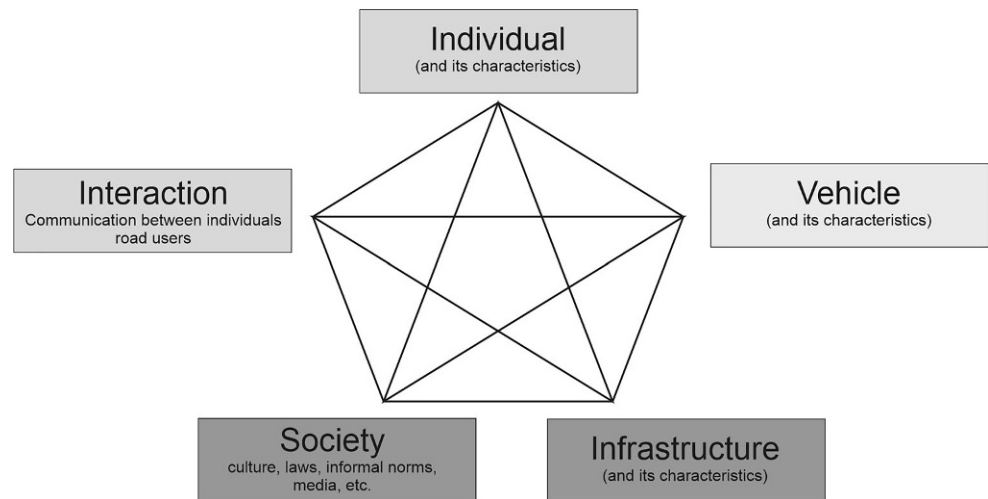
In sum, there is an extensive body of rules and regulations that explains the requirements for the design of a safe traffic facility in a wealth of design options and their associated modes of action, but leaves them to be weighed up by decision-makers, be they experts or laypeople, without any dominant prioritization.

In addition, the regulations assume that road users are attentive and act rationally and in accordance with the rules, and that the infrastructure is provided for them. This means that essential basic components of the transport system are not addressed.

Chaloupka-Risser et al. (2011) describe four further areas besides infrastructure that have an influence on transport behaviour (cf. Fig. 1). In addition to the influence of the infrastructure and its characteristics such as dimensions,

Fig. 1 Basic building blocks of the transport system as a division into individual, communicative, structural, infrastructural and specific elements for the mode of transport with an influence on transport behaviour according to Chaloupka-Risser et al. (2011)

Abb. 1 Grundbausteine des Verkehrssystems als Unterteilung in individuelle, kommunikative, strukturelle, infrastrukturelle und verkehrsträgerspezifische Elemente mit Einfluss auf das Verkehrsverhalten nach Chaloupka-Risser et al. (2011)



equipment and traffic regulations, there are also the characteristics of the vehicle—here, for example, the bicycle. In this context, the diversity of bicycle types that has arisen in the meantime has not yet been considered. Other aspects such as society with its culture, laws and norms including their acceptance or compliance as well as the interaction between road users can only be identified to a limited extent in the set of regulations. And finally, the wide range of personal characteristics is hardly considered in the set of rules. In particular, the age of cyclists—from children to senior citizens—subsumes substantial differences in physical and cognitive abilities and special protection needs in the margins of the spectrum. But even in the large group of adult cyclists, different types of cyclists show up, with specific characteristics regarding the basic building blocks of the transport system (cf. e.g. Francke and Lißner 2021).

The abundance of requirements, criteria, information, modes of action, methods, and legal requirements seems to overwhelm the decision-makers, as the multitude of criteria and the lack of a clear prioritisation makes it difficult to classify the importance of each individual criterion. This seems to favour that despite existing expertise and political will, the creation of good cycling infrastructure is not or only insufficiently carried out.

On the way from the diverse, substantively justified requirements for a safe infrastructure to its implementation, a set of instruments is therefore needed that enables pragmatic decisions for a traffic-safe infrastructure.

2 A question of decision: the decisive question

Two anonymized examples from planning practice may provide a pragmatic help in the decision-making process regarding safe bicycle road infrastructure.

A local thoroughfare is to be redesigned and—newly—shall provide a cycling infrastructure to enable safe and attractive cycling. The commissioned planners were given further framework conditions for the design, which included in particular a high traffic quality for motor vehicle traffic and the limitation to the existing areas. The draft prepared by the expert planners (cf. Fig. 2) provided for the marking of a 1.25 m wide advisory lane for bicycle traffic, applying the minimum dimensions in the associated guideline. The vehicle lanes were made slightly narrower. A turning lane was retained for the benefit of traffic flow. A total of 15,000 vehicles uses the road daily, of which approx. 1000 are trucks.

According to the current regulations, various aspects of road safety for cycling have been subordinated to the preservation of all motor vehicle traffic. With the existing traffic volumes, separate cycle lanes are required at 50 km/h speed limits. However, even with a 30 km/h limit, advisory lanes are to be avoided but not ruled out due to the high volume of heavy traffic. More importantly, according to the current German traffic code (StVO), a distance of at least 1.50 m must be maintained within built-up areas and 2 m outside when overtaking cyclists. This also applies to advisory lanes (Müller 2018). It can be concluded from this that cyclists are not overtaken if motor vehicle drivers behave in accordance with the traffic code and thus determine the flow of traffic on the local thoroughfare, as there is a de facto ban on overtaking. In this respect, the decision to maintain a left-turn lane and thus the minimisation of the cycling space in an advisory lane is counteracted in the case of traffic behaviour that conforms to the rules.

In reality, it cannot be assumed that such a ban on overtaking is observed. Rather, it can be assumed that cyclists are overtaken with lateral distances of less than 1 m, favoured by the design of the infrastructure (cf. Mros 2021).

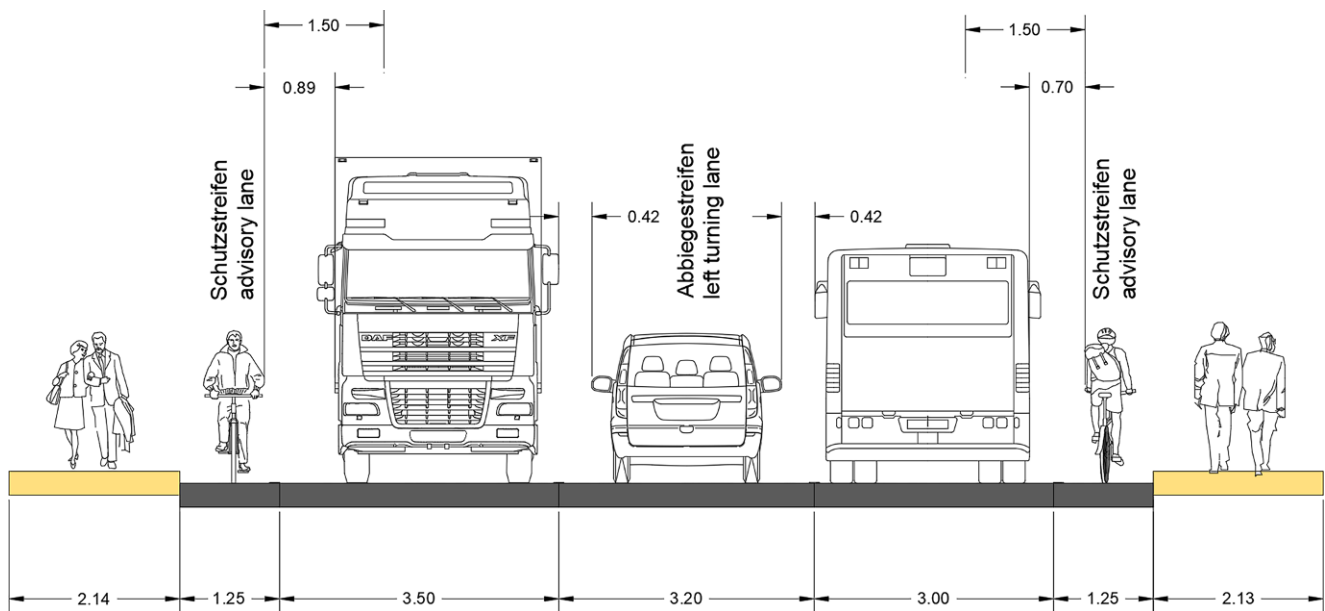
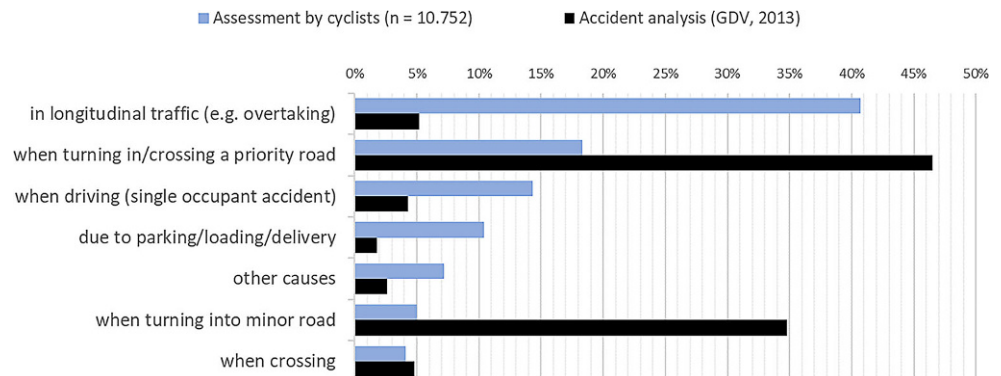


Fig. 2 Proposal of an insufficient but politically approved technical planning for the cross-section of a through road with bicycle traffic. The required safety space to bicycle traffic (1.50 m) will not be given in practice. Cyclists will feel unsafe. (Own illustration)

Abb. 2 Vorschlag einer ungenügenden, aber politisch abgestimmten Fachplanung für den Querschnitt einer Durchgangsstraße mit Radverkehr. Der erforderliche Abstand zum Radverkehr (1,50 m) wird in der Praxis nicht eingehalten werden. Die Radfahrer werden sich nicht sicher fühlen. (Eigene Darstellung)

Fig. 3 Cyclists risk-assessment and analysis of bicycle accidents in Germany 2013. (Own illustration based on: Steinig and Wigand-Steinmetz 2021)

Abb. 3 Risikoeinschätzung durch Radfahrende im Vergleich zu Unfallursachen im Radverkehr in Deutschland 2013 (eigene Darstellung auf der Basis von Steinig and Wigand-Steinmetz 2021)



Apart from the fact that undercutting the safety distance is not in compliance with the rules or is illegal, the overtaking distance is the essential aspect of the subjective perception of safety. Even though accident statistics show turning into another road as the most frequent causes of accidents, people rate the risk in longitudinal traffic—i.e. overtaking or vehicle doors opening (dooring)—as the highest (cf. Fig. 3).

The combination of the requirements—additional safe traffic space for cyclists and at the same time unchanged traffic flows for motor vehicles—cannot be fulfilled in a meaningful way. The apparent compliance with the minimum requirements leads to traffic violations when cyclists are overtaken. The subjective feeling of safety of cyclists is impaired, and objectively no traffic-safe facility for cycling is created. The objective of a safe and more comfortable or inviting cycling infrastructure was subordinated to the

traffic flow for motor vehicle traffic. In the combination of requirements, allowed minimum dimensions, an apparent overriding of parts of the regulations and the presentation by a specialist planner, the decision-makers were hardly able to judge whether the original objective—safe and attractive cycling—had been achieved.

A simple, pragmatic basis for assessment was needed, which was finally found in the form of a personal question:

“Would you let your 11-year-old child ride a bike there?”¹

¹ Background: In Germany, children from the age of 11 must cycle on the road or on designated infrastructure.

Fig. 4 Overtaking distances bicycle—motor vehicle sharing an outside road. (Own illustration based on Gliniorz et al. 2022)

Abb. 4 Überholabstände Fahrrad – Kraftfahrzeug bei gemeinsamer Nutzung einer Außenstraße. (Eigene Darstellung basierend auf Gliniorz et al. 2022)

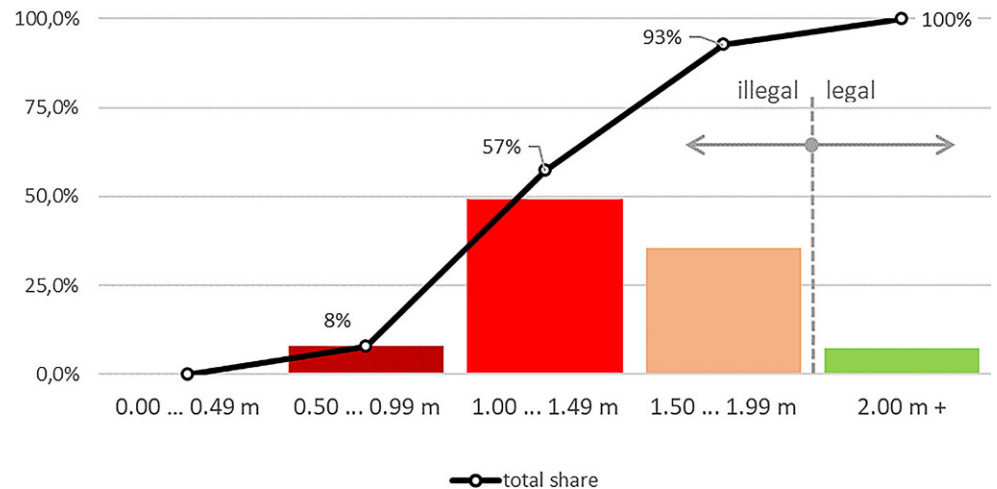
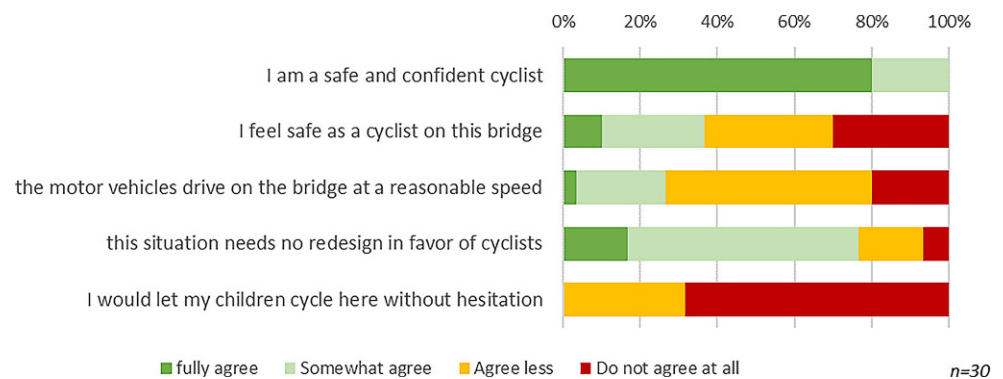


Fig. 5 Cyclists situation assessment about an extra-urban road where cyclists share the road with motorized traffic. (Own illustration according to Gliniorz et al. 2022)

Abb. 5 Situationseinschätzung von Radfahrern auf einer außerstädtischen Straße, auf der sich Radfahrer die Straße mit dem motorisierten Verkehr teilen. (Eigene Darstellung nach Gliniorz et al. 2022)



This question was—of course—answered in the negative, which immediately made it clear that this planning does not fulfil the objective for cycling. The planning is now under revision.

The discrepancy in weighing up the assessment of cycling infrastructure from a personal overall perspective taking into account other experiences (e.g. as a car driver) versus a potential safety-focused decision by those potentially affected can be illustrated by another example.

On a rural road out of town, cycling traffic shares the road with normal car traffic. The 400m long section of road includes a bridge over the motorway and does not offer a financially viable upgrade option in favour of cycling. Therefore, the proposal is to reuse one lane of motor traffic as a cycle path. This requires a restriction of motor vehicle traffic, as it then travels the 400m long distance in alternating directions under traffic light control. The potential restrictions on motor vehicle traffic were strongly criticised in consultation with the local committees, which is why a temporary installation of the measure was suggested on an experimental basis. In the run-up to the experiment, the overtaking distances of motor vehicles to cyclists were measured (cf. Fig. 4). According to the road traffic regulations, the minimum distance required to overtake a bicycle

is 2.0m. In the section of road studied, this distance was only observed in about 7% of the cases. About 35% of the overtaking distances were between 1.5 and 2.0m. 50% of the distances were measured at 1.0 and 1.5m and would therefore also be insufficient in built-up areas. 8% of the overtakes took place at a distance of less than 1.0m. The smallest distance measured was 0.65m.

The small overtaking distances are also reflected in the cyclists' perception of safety (cf. Fig. 5). Most cyclists do not feel safe in this area and the speeds of motor vehicle traffic are also viewed critically by cyclists. Nevertheless, a change in favour of cyclists is not considered necessary by the majority. Only the reference to their own children makes it clear that a safety deficit is very much seen: No one would let their children cycle there without worrying.

This harmonises the assessment of cycling infrastructure in terms of road safety.

This question, or rather the answer to it, resulted in the necessary approval for the traffic trial in favour of the measure for the road safety of cycling traffic, while restricting the traffic flow for motor vehicle traffic, in the local council meeting.

3 Conclusion

The exemplary cases described show, in accordance with the literature, that good cycling infrastructure can only be developed to a certain extent from the existing regulatory framework. The aspects of the transport system, the abundance of competing demands as well as the transfer of balancing decisions to laypeople are aspects that need to be given more consideration in a decision-making process for building infrastructure.

In the knowledge of the cyclists needs and the requirements of a safe and attractive design of cycling infrastructure, there is no significant lack for most situations.²

The gap between the expert knowledge of good cycling infrastructure and the development of such infrastructure must be closed, especially in the decision-making. In this context, it is important to formulate a suitable task or question for the consideration, which enables a targeted decision even without detailed knowledge of the regulations and guidelines.

For cycling, the question of the suitability of cycling facilities for one's own children or grandchildren seems to be helpful. In this way, subjective concerns and emotionality are addressed and a change of perspective is forced. The perspective of the supposedly safe driver and his demands, who in his own perception poses no danger to others, becomes the perspective of a potentially emotionally threatened person. In this case, the supposed harm is so immeasurably high that the probability of the harm occurring must be set to zero to minimise the risk. From the planner's point of view (knowledge) and the cyclist's point of view (experience), a high degree of agreement with the decision-maker is achieved.

It would have to be approved which superordinate goals, potential situations or addressing enable the decision-makers to make a decision that is valuable and communicable for them although the abundance of competing aspects. We already apply such mergers of diverse aspects in other use cases of everyday life (e.g. NutriScore, energy label, ...).

Overall, the appropriate addressing of the decision-making processes and the decisive people in the design of our living environment could make a significant contribution to sustainable change. Especially in the field of transport and mobility, which is prepared rationally by technical planning, but which is also decided emotionally by politics, society and individuals, there is great potential in the combination

of engineers and social psychologists to turn knowledge into action that reduces uncertainty and improves traffic safety.

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² This is valid even if the current guidelines do not yet decisively represent the range of different types of cyclists and bicycles that now exist. The guidelines are under revision in this respect and will be issued next year.